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Pacific Southwest Region

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TREE MORTALITY ON THE CLEVELAND NATIONAL FOREST

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ABSTRACT

Tree mortality has recently increased on all three Districts of the Cleveland National Forest. Substantial mortality has occurred in native stands of Coulter pine, Jeffrey pine and white fir as well as in plantations of Coulter pine, Jeffrey pine and knobcone X Monterey pine. Most of the trees that died had been attacked and killed by cambium-feeding insects. These trees were probably predisposed to attack by stress associated with stocking levels which were high for the sites, competition from native brush and grass, and the lower than normal amount of precipitation received from mid-1980 through late-1981. Annosus root disease was involved in tree mortality in a few spots, and western dwarf mistletoe infections were widespread on Laguna Mountain. Management options describe the consequences of no action and cover short-term and long-term actions that can be taken to relieve the situation.

INTRODUCTION

The Forest Supervisor of the Cleveland National Forest requested an evaluation of mortality areas on the Descanso, Palomar and Trabuco Ranger Districts. On March 8-10, 1982, Dave Schultz and James Allison of the Forest Pest Management Staff examined the areas of concern. They were assisted during various portions of the trip by Tom Grigery, Inez Robbins, Gene Blankenbaker, Ernie Martinsen, Nelson Dean and others from the Cleveland National Forest; Jim Bridges, Forest Silviculturist, San Bernardino National Forest; and Ken Slater, South Zone Timber Management Specialist.

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OBSERVATIONS

Descanso Ranger District. Most of the mortality on Laguna Mountain was occurring in native stands of Coulter and Jeffrey pine. Western dwarf mistletoe infections were widespread on the pines in the area and quite heavy on individual trees. Some of the pines were also infected with elytroderma disease, caused by Elytroderma deformans. Annosus root disease centers, caused by the fungus Fomes annosus, are very common on Laguna Mountain and are involved in some of the current mortality. A more widespread cause of tree stress in the area is competition for water from grass and brush. The amount of competition for water is particularly significant at this time because the precipitation records from two reporting stations near Laguna Mountain (Descanso Station and Cuyamaca - See Appendix) show that the precipitation received in most months from June 1980 through November 1981, was below the long-term average. Precipitation received at Descanso Station was below the monthly average for 15 of the 18 months from June 1980 through November 1981, and the total amount received was 69 percent of normal for that period. Precipitation at Cuyamaca during the same period was below normal for 13 of the 18 months and totaled 65 percent of normal. The combination of diseases in the stands and water stress have permitted many trees to be successfully attacked by the California flatheaded borer, Melanophila californica. There were also some pines that were scorched at their base during a prescribed burn that had been successfully attacked by the red turpentine beetle, Dendroctonus valens. The success of the turpentine beetles is probably related to both the cambial injury and the low available soil moisture.

In one plantation, numerous incense-cedar saplings had most of the foliage killed by spider mites. The mite outbreak appears to be unrelated to the soil moisture or recent management activities, although the damage the mites produced might have been more severe than usual in view of the stressed condition of the trees.

Palomar Ranger District. Numerous small plantations have been installed on Black Mountain between 2800 and 4000 ft. elevation during the past 15 years. Blocks have been cleared in the native vegetation, consisting largely of chamise and yucca, and then planted with Coulter pine, Jeffrey pine, knobcone X Monterey pine, other hybrid pines, giant sequoia and incense-cedar. Many of the knobcone X Monterey pines in the lower-elevation plantations died recently. There were no signs of insects, diseases or animal damage on the dead trees. The root systems of several trees that were excavated seemed rather small and compact for the size of tree they were supporting, indicating that the trees may have been root-bound potted seedlings when they were planted. Most of the dead seedlings had the foliage "frozen" in a downslope position and the roots were loose in the soil. This suggests that the cause of death was extreme water loss, caused by Santa Ana winds, which could not be compensated for by the small root systems.

The plantations at higher elevations were older and had better survival. Some thinning and brush removal had taken place, although some spots currently have interlocking tree crowns and/or substantial brush competition.

The records from two nearby stations (Palomar Mountain Observatory and Henshaw Dam - See Appendix) show that precipitation was below the long-term normal for most months from June 1980 through November 1981. Precipitation received at Palomar Mountain was below normal for 16 of the 18 months from June 1980 through November 1981, and the total amount received was 54 percent of normal for that period. Precipitation at Henshaw Dam during the same period was below normal for 13 of the 18 months and the total was 80 percent of normal. The combination of stresses from the relatively high amount of vegetation and low amount of soil moisture available on these sites have led to successful attacks on some of the knobcone X Monterey and Coulter pines by pine engravers, Ips spp., and twig beetles, Pityophthorus spp. Attacks by the pine engravers generally led to mortality in groups, while the twig beetle attacks were on single trees. There has also been a recent increase in tree mortality on Palomar Mountain. So far, the mortality has been limited to some non-native pines planted along the County roads and top-killing of white fir by the fir engraver, Scolytus ventralis, near the Palomar Observatory.

Trabuco Ranger District. The El Cariso Penny Pines plantation and campground are located at about 2800 ft. elevation. The native vegetation in the area consists of brush, grass and yucca, with some live oak in the moist draws. Over a period of years the area has been planted with knobcone X Monterey pine, Coulter pine and some cypress. Some of the stock was still in tarpaper pots when planted and the root masses were largely confined to the pot after five or more years of growth. The plantation has been watered in the past, but the water delivery system is apparently not fully functional at the present time. Some thinning and hand removal of brush has occurred, although the total amount of vegetation remaining in the area appeared to be substantial, considering the site. Precipitation records for the immediate area are not available. The two stations with long-term records closest to El Cariso (Corona and Yorba Linda - See Appendix) are located 18-30 miles away and over 2000 ft. lower in elevation. The amount of precipitation received at these stations is probably lower than at El Cariso, but the pattern should be similar. The records from these stations indicate that the amount of precipitation received during most months from mid-1980 through late-1981 was lower than the long-term average. Precipitation at Corona was below normal for 17 of the 18 months from June 1980 through November 1981, and the total amount received was 56 percent of normal. The station at Yorba Linda received below-normal precipitation for 15 of the 18 months, for a total which was 52 percent of normal for that period. The combination of the site, stand conditions and reduced available moisture permitted pine engraver beetles to kill some groups of Coulter pine and knobcone X Monterey pine. Additional trees have been attacked in the area but they have not faded yet. Some individual smaller pines are currently being attacked by twig beetles.

Several other situations were examined along the Main Divide road in which stand conditions combined with low precipitation have allowed native insects to attack and kill trees. In a brushy canyon near the Blue Jay Campground, several live oaks were dying due to attacks from oak bark beetles, Pseudopityophthorus spp., and borers. These beetles are usually considered secondary insects because they attack only declining oak trees. The trees examined had no indication of root disease or other debilitating

factors except moisture stress. One small plantation of pole-size Coulter pine and hybrid pines was examined. The plantation had been thinned without any type of slash disposal. Apparently engraver beetles populations built up in the slash and then emerged to kill some of the remaining trees. Engraver beetles had also caused rather extensive damage to other plantations which had heavy competition from manzanita; to remnants of Coulter pine stands around a fairly recent burn; and to a pole-size stand of Coulter pine at Maple Springs. In the stand at Maple Springs, there were a few stumps, which are the result of past insect control projects, that are infected with annosus root disease. The major problem here, however, seemed to be moisture stress which was aggravated by dense manzanita.

DISCUSSION

The underlying factor which is common to the recent mortality on all three Districts is the below-normal amount of precipitation received from mid-1980 through late-1981. Additionally, there are several conditions which when coupled with the moisture deficit have increased the amount of current mortality above that which might otherwise be expected. The last period of high and widespread tree mortality in southern California was during the early 1970's, which was also a period of deficient precipitation. Since then, precipitation has been near normal through 1977, and far above normal from 1978-1980. The very high amount of precipitation during 1978-1980 was accompanied by a very low amount of tree mortality. Part of the reason the current mortality is so high is because it represents a backlog of several years of tree mortality that was delayed by the above-normal amount of moisture available from 1978-1980. During the same period of high precipitation, the basal area of stands and the amount of brush and grass increased in most areas, which eventually increased the competition for moisture. Another factor which seems to be related to the current amount of mortality is that some of the plantations were planted with non-native trees during years of normal or above-normal precipitation in areas which show no evidence of having supported conifers in the recent past. There are probably many sites on the Forest that have adequate soil, exposure and precipitation or subsurface moisture to support conifers, but currently lack them because the proper seed source is missing. The condition of some of the existing plantations suggests that some of them will not support conifers without constant maintenance or perhaps conversion to a tree species better adapted to the local conditions.

The immediate cause of death of most of the trees examined was successful attacks by one or more species of cambium-feeding beetles. Some of these beetles, such as the red turpentine beetle and twig beetles, are normally considered secondary insects because their attacks generally result in limited injury to a healthy tree. The California flatheaded borer initiates attacks by laying eggs in the bark crevices of trees. After the eggs hatch, the larvae penetrate the bark to the cambium. The cambium of healthy, vigorous trees will quickly overgrow the larvae with little damage to the tree. Larvae boring in weakened, stressed or diseased trees can kill the tree in as little as a year, or they may slowly mine in the cambium for several years until the tree becomes weak enough for them to overcome it. It would be rare for flatheaded borers to attack a healthy, vigorous tree and kill it in a period of one year. Pine engraver beetles

are considered primary insects because they can rapidly kill healthy, vigorous trees, but they are also opportunists which readily breed in fresh slash or drought-stressed pines. Populations of these beetles fluctuate rapidly due to multiple generations per year and a total generation time as short as 45 days during the summer. The pine engravers also have a powerful pheromone attractant system which can draw large numbers of the beetles toward the site of a successful attack. This combination of characteristics that engraver beetles possess can lead to some spectacular group kills of trees in areas where fresh pine slash is left untreated or where a few severely stressed trees can form the center of a group kill.

Because most of the current mortality is directly related to the moisture deficit of mid-1980 through late 1981, it most likely will not subside until precipitation returns to normal. The measures that could be taken immediately to reduce mortality are somewhat limited. Plantations which have a heavy cover of grass could be spot sprayed with herbicide around the trees to make more moisture available to the trees. Herbicide treatment would not add any moisture to the soil but will help conserve what is already present. In a similar fashion, brush control by hand cutting or herbicide application would make more water available to trees. Thinning the plantations where the crowns are beginning to interlock would have a beneficial effect on moisture distribution, but the disturbance and sudden exposure could increase tree stress, and any untreated slash could lead to an increase in engraver beetle populations. If there were some assurance that precipitation would return to normal next fall and winter, it might be safer to postpone thinning until soil mositure is adequate, rather than risk the possibility that thinning activities during a period of moisture deficit would lead to an unacceptable level of mortality in the leave trees. Unfortunately, it seems common for periods of below-normal precipitation to last for several years in southern California, so extensive losses could occur to stands while waiting for adequate precipitation to return. Regardless of when the plantations are thinned, it would be advantageous to cause the least amount of disturbance possible and to treat the slash to prevent engraver beetle buildups. A method which could be used to prevent the loss of individual high-value pines, such as in campgrounds or around facilities, would be to treat the boles of selected trees with insecticide. Sevimol-4* is registered for use on pine trees and it has prevented the attacks of most bark beetles and borers where it has been used in California. The treatment is effective for only a year and it does nothing to correct the stand or site conditions that made the tree susceptible to beetle attack in the first place. The cost of treatment would vary with the availability of local contractors, among other factors, but it is unlikely that any bids would be less than $3.50 per tree due to material and labor costs.

Once precipitation returns to normal, mortality should subside. The level that it stabilizes at will probably be higher than it could be, because of the presence of stand conditions and diseases which reduce tree vigor. In

* The use of a trade name is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service.

its ongoing stand management activities, the Forest has already begun integrating measures for improving stand vigor and reducing the impact of diseases. Examples of steps taken by the Forest include brush removal and thinning of plantations with interlocking crowns to make more moisture available to the leave trees, the application of borax to freshly cut stumps to prevent infection by Fomes annosus, and, as on Laguna Mountain, pruning dwarf mistletoe brooms to increase tree vigor. If these measures can be continued and extended to other stands where they are applicable, it will probably lower the level of mortality during periods of normal precipitation and put the stands in a better position to survive future drought periods.

MANAGEMENT OPTIONS

1. Do Nothing. Tree mortality levels will remain high until precipitation returns to normal. Trees which have additional stresses from disease or competition have the greatest probability of dying. Mortality will return to lower levels after precipitation returns to normal, but then some stands which have diseases or competition will have higher mortality levels than the more intensively managed stands.

2. Fall and burn currently dead trees. The major effect of falling and burning the currently dead trees would be to deprive the local firewood market of wood. The widely scattered nature of the dead trees, the number of secondary insects involved in the mortality and the low vigor of the surviving trees all suggest that direct control of beetles would have a minimal impact on future mortality.

3. Salvage dead trees. This option will remove dead trees, which would enhance the scenic value along roads, realize some economic value from the killed timber, and/or provide firewood. Most of the areas to which the firewood would be taken are far enough from conifer stands that little mortality to homeowners' trees would be expected from beetles emerging from the logs.

Under this option mortality can be expected to continue, necessitating repeated salvage. Additionally, disturbance in the moisture-stressed stands might increase the susceptibility of trees to insect attack. Any green pine slash laid on the ground before mid-July would tend to increase or maintain the pine engraver populations.

4. Treat selected trees with insecticide. Thorough coverage of the bole, leader, and main branches of high-value pines with Sevimol-4 would protect over 90% of them from beetle attack for up to a year. The treatment would do nothing to alter the conditions that made the trees susceptible to insect attack, but it would protect an investment and buy some time until silvicultural treatments could take place. An Environmental Assessment and Pesticide-Use Proposal would be required prior to treatment.

5. Integrate pest management considerations with stand prescriptions. Stand treatments will not end the current episode of high mortality, but will aid in lowering the "background" rate of mortality and minimize tree mortality during future periods of moisture stress. The integration of

pest management considerations with stand prescriptions should bring about and maintain a low level of tree mortality during years of average or above-average rainfall, and prevent widespread tree mortality during periods of drought. However, some tree mortality will continue, especially in existing root disease centers and in stands with trees that are high insect risk and/or heavily infected with dwarf mistletoe.

Specific components of an integrated pest management system that appear appropriate include the following:

a. Borax stump treatment. *Fomes annosus* was involved in some of the mortality observed. Where present, it plays a key role in predisposing trees to successful insect attack. New infections can be prevented by applying borax to freshly cut stumps of live or recently killed trees. The freshly cut stump surface must be completely covered with borax soon after cutting to make the treament effective. Treatment of all freshly cut conifer stumps with borax is required in and near recreation sites (FSM R-5 Supp. 2305 and 2331.5).

b. Thinning. Thinning is an effective stand treatment for the prevention of bark beetle-caused mortality. The beneficial effect of thinning is especially apparent during periods of stress, such as periods of below-normal precipitation. Thinning can also be an important tool for minimizing the effects of dwarf mistletoe on Laguna Mountain. The pathogen becomes especially damaging in stands that stagnate. Spacing control allows the trees to grow proportionally faster in height than the parasite moves upward in the tree. If the thinning is done when the stems are small, the likelihood of annosus infection of the stump will be decreased.

Basal area thinning guidelines are not available for specific pests. However, it is reasonable to expect that a level of thinning that results in the maintenance of good radial growth, height growth and a full crown will make the trees resistant to insect attack. Pine slash created during thinning can be treated by one of the methods listed in the appendix to prevent a buildup of engraver beetles and subsequent mortality in the area.

c. Mixed stands. No feasible means of eradicating *F. annosus* from an infection center are known, so centers of mortality can be expected to enlarge indefinitely as roots of susceptible trees become infected at the margins of the center.

The effects of the fungus can be minimized, however, through the use of resistant species. Most hardwoods are resistant to the disease, and naturally occurring species may be successfully grown in openings created by the disease.

The encouragement of mixed stands is also a good dwarf mistletoe management technique. Given the narrow host range of most of the dwarf mistletoe species, it is frequently possible to encourage non-host species when thinning or planting. The western dwarf mistletoe present in the Coulter and Jeffrey pines examined can also infect ponderosa and knobcone pine, but other conifers and hardwoods are immune.

d. Prescribed burn pre-treatment. The loss of some tress in a prescribed burn on Laguna Mountain suggests that it might be worthwhile to remove flammable material or rake firelines around valuable trees prior to burning.

e. Control dwarf mistletoe on Laguna Mountain. Previous surveys have shown that about 2,400 acres of National Forest land on Laguna Mountain with a high recreation potential are infected with dwarf mistletoe. Under long-rotation, all-age management with natural regeneration, dwarf mistletoe infections can interfere with management objectives. A number of dwarf mistletoe control projects involving removal of heavily infected trees or pruning have occurred in the past. Further dwarf mistletoe control work would extend the life of some trees and put stands in a better position to survive future drought periods.

f. Match future regeneration stock to site. Progeny of native trees from the same seed zone and similar elevation have a reasonable chance of being adapted to the local environment. Using native stock will not totally solve pest problems, but the trees will respond in a more predictable manner than exotic or hybrid trees will.

Options 3 through 5 are not mutally exclusive and could be used in combinations where appropriate to achieve the management objectives for a particular stand.

Please contact the Forest Pest Management Staff (telephone 415-556-6520) if clarification is needed for any part of this report or if assistance is needed in applying these management options to any site-specific situation.

APPENDIX

I. BIOLOGY OF MAJOR ORGANISMS

PINE ENGRAVER BEETLE

Pine engravers (*Ips* spp.) will breed either in the tops of live pine trees or in fresh green slash. Attacks on live trees are usually limited to trees which are suppressed, or stressed by dwarf mistletoe, root disease, drought, fire, or the attack of other insects. If fresh slash is available in the spring, pine engraver populations may build up in it and and cause locally heavy top killing by mid-summer. Attacks are made with the coming of warm weather in the spring. A new generation is produced in 6-8 weeks in the spring, to 4-6 weeks in mid-summer (August). Thus, several overlapping generations per year may be produced. The winter may be passed in any of the life stages of larvae, pupae, or adults, depending upon species involved.

Outbreaks in standing, healthy trees are sporadic and of short duration, and are often associated with some temporary stress or shock afflicting the host species, such as severe competition or sudden opening of the stand. Tree killing frequently occurs where green pine slash, which serves as breeding habitat, is left untreated during spring and summer.

Fresh pine slash caused by thinning, dwarf mistletoe control work, construction damage or winter storm breakage can be modified in a number of ways to make it unsuitable for pine engraver breeding. One approach to minimizing damage is to schedule slash-generating activities mostly between mid-July and late December, when the slash has a high probability of drying out before the beetles can complete their development. Green pine slash created during the spring and early summer should be treated to prevent the buildup of pine engraver populations. Because pine engravers can complete their development in about a month under ideal conditions, treatment should be carried out soon after cutting to be effective. Some methods of slash treatment that might be acceptable in dispersed recreation areas would include lopping and scattering slash in sunny areas to speed its drying, crushing or mashing slash with logging equipment to make it unsuitable for pine engraver breeding, or piling and burning the slash within a month of cutting. Broadcast burning the slash might work if it could be done while the slash is green without damaging the residual stand. Another method which might work is to pile slash in a sunny area and tightly cover the pile with clear plastic. If the temperature under the bark of slash in all parts of the pile reaches 120^{0}F, all brood currently in the pile will be killed. Lower temperatures will not be effective and, where successful, this method will not prevent reinfestation of slash piles. The most acceptable methods of slash treatment in high-use recreation areas would probably be disposal by chipping or removal from the site.

CALIFORNIA FLATHEADED BORER

The California flatheaded borer (*Melanophila californica*) principally attacks Jeffrey and ponderosa pines, although it may be found in other pines. It is most severe in stands located on sites where environmental stress is common. Decadent or unhealthy trees are most frequently attacked, along with an occasional top of a thrifty, vigorous tree.

Eggs are laid in bark crevices of the host tree. Newly hatched larvae penetrate directly through the bark to the phloem. Here the larvae may feed from a few months to 4 years without any apparent effect on the host tree. Should host vigor and larval abundance not allow them to succeed, the larvae cut very short galleries before they are killed. These galleries do not seriously injure the tree and are overgrown by the cambium. Should conditions be, or become, unfavorable for the tree and favorable for the larvae, the larvae develop rapidly and destroy the cambium.

ANNOSUS ROOT DISEASE

Fomes annosus is a fungus that infects a wide range of woody plants, causing decay of the roots and butt and the death of sapwood and cambium. All conifer species in California are susceptible to the fungus. Hardwood species are rarely damaged or killed. Madrone (*Arbutus menziesii*) and a few brush species (*Arctostaphylos* spp. and *Artemisia tridentata*) are occasional hosts.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or in the duff at the root collar. The fungus becomes established in freshly cut stumps from airborne spores produced by the conks, and then grows into the root system. The fungus subsequently spreads to healthy roots of surrounding susceptible species *via* root contacts. Local spread of the disease outward from an infected stump typically results in the formation of a disease center, with stumps and older dead trees near the center and fading trees on the margin. The centers continue to enlarge until they reach barriers, such as openings in the stand or groups of nonsusceptible plants.

The fungus may remain alive for as long as 50 years as a saprophyte in infected roots and stumps. Young susceptible trees invading the site often become infected and die after their roots contact old infected root systems in the soil.

WESTERN DWARF MISTLETOE

Western dwarf mistletoe (*Arceuthobium campylopodum*) infects Jeffrey, ponderosa, knobcone, and Coulter pines. Other conifers or hardwoods are not infected by this particular species. Dwarf mistletoes are obligate parasites that are completely dependent on their host for

support, water, and most of their mineral and organic nutrients. They often cause the formation of "witches' brooms", dense masses of distorted branches, on the host that divert nutrients from the rest of the tree. Infection can cause growth reduction, abnormalities, mortality and predisposition to attack by other pests. In particular, infected trees appear to be more susceptible to attack by bark beetles and the California flatheaded borer than do uninfected trees. The dwarf mistletoe/bark beetle complex is responsible for 40 to 60% of the pine mortality in southern California during years of normal precipitation. Mortality is more frequent when other stress factors occur, such as drought, oxidant air pollution damage, or competition in overstocked stands.

Dwarf mistletoe spreads between trees and within crowns of trees by means of small seeds that are forcibly ejected into the air. Spread from overstory to understory is limited to the distance the seeds are shot, generally 20 to 60 feet, but as much as 100 feet if assisted by wind, or on steep slopes. Horizontal spread in an even-aged pine stand averages one to two feet per year with a vertical spread rate up the crown at about four inches per year.

PRECIPITATION AT DESCANSO STATION - 3500 FT. (DESCANSO R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	1.33	1.30	5.43	1.46	.02	T	T	.00	.00	.00	4.87	4.09	18.50
71	1.80	2.86	.77	1.49	1.83	.00	.01	.61	.18	1.83	.33	6.58	18.29
72	.00	.50	.00	.59	.63	.86	.00	.02	.53	3.10	4.40	4.93	15.56
73	3.94	5.42	9.15	.57	.23	.00	.00	.01	.00	.02	2.03	.47	21.84
74	6.87	.20	2.87	1.13	.08	.00	.41	.00	.14	5.06	1.04	1.90	19.70
75	.72	2.71	7.31	3.56	.36	.22	.04	.00	.96	.33	2.97	1.43	20.69
76	.00	7.92	3.89	3.64	.12	.10	2.03	.00	1.45	1.42	1.00	1.97	23.54
77	3.64	.81	3.15	.40	3.45	.00	T	1.80	.00	.90	.40	5.16	19.71
78	9.85	9.31	11.05	3.20	.85	.00	T	.02	.34	.02	4.64	6.15	45.43
79	9.22	4.95	8.79	.30	.50	.00	.27	.05	.14	3.22	.55	.84	28.83
80	16.22	16.18	5.18	2.47	1.40	[.00	.00	.00	.00	1.18	.00	1.45]	44.08
81	[1.79	3.71	6.22	1.92	.15	.00	.00	.00	-	.46	1.76][1]		
AV	3.94	3.42	4.17	2.73	.83	.11	.24	.42	.30	.74	2.32	3.56	22.78

[1] Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 15 months with below-normal rainfall and a total deficit of 8.27 inches, or 69 percent of normal for that period.

PRECIPITATION AT CUYAMACA - 4640 Ft. (Descanso R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	1.90	.95	8.56	2.53	.01	.06	.09	.46	.02	.46	6.21	8.00	29.25
71	3.00	2.55	1.19	4.26	3.29	.00	.06	.97	.24	3.61	.36	11.61	31.14
72	.19	.67	.00	1.17	1.30	1.39	.04	.02	.62	4.15	7.02	6.02	22.59
73	7.57	9.29	14.31	1.24	.91	.05	.00	1.54	.00	.14	4.88	.65	40.58
74	7.82	.50	4.07	2.21	.38	.00	2.68	.05	.20	5.65	1.36	3.46	28.38
75	1.17	4.17	8.68	7.17	.62	.27	.09	.00	2.15	.58	5.10	1.45	31.45
76	.08	11.80	3.94	3.52	.18	.19	.52	.00	7.12	1.60	1.32	2.56	32.83
77	5.02	1.40	3.49	.53	5.04	.08	.00	4.10	.00	1.30	.92	6.80	28.68
78	12.46	12.27	14.65	4.42	.89	.00	.00	.18	.91	.48	6.67	7.77	60.70
79	8.36	7.45	8.50	.14	1.57	.00	.37	.58	.37	5.06	.79	1.94	35.13
80	23.37	24.34	9.70	4.09	3.39	[.07	.64	.00	.00	1.51	.01	2.37]	64.49
81	[2.68	4.07	4.61	1.27	1.45	.00	T		1.14	2.69	.96	2.75][1]	
AV	5.59	5.41	6.13	3.66	1.10	.15	.51	.52	.58	1.03	3.54	5.70	33.44

1 Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 13 months with below-normal rainfall and a total deficit of 14.03 inches, or 65 percent of normal for that period.

PRECIPITATION AT PALOMAR MOUNTAIN OBSERVATORY 5550 FT. (PALOMAR R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	1.57	2.19	9.59	1.34	.00	.00	.00	4.74	.00	.35	5.02	7.76	32.56
71	2.51	1.51	.85	1.79	1.72	.01	.00	.30	.00	1.94	.38	8.91	19.92
72	.00	.67	.00	1.03	.70	1.70	.02	.00	.00	1.86	6.11	6.39	18.48
73	5.47	7.80	8.60	.00	.00	.00	.00	.19	.00	.00	4.66	.50	27.22
74	4.28	.00	5.05	1.48	.00	.00	1.49	.13	.74	4.04	.12	11.00	28.33
75	.25	2.48	9.93	4.64	.25	.00	.00	.00	.57	.54	2.65	.69	22.00
76	.00	11.11	4.49	2.93	.50	.00	1.20	.00	6.42	.14	1.15	1.96	29.90
77	7.31	1.23	4.24	.65	4.61	.04	.16	4.24	.00	.00	.00	7.73	30.21
78	19.18	13.11	15.36	4.22	.28	.00	.00	.00	1.84	.83	3.97	6.15	64.94
79	8.37	7.13	13.04	.04	.00	.06	1.10	.74	.00	3.47	.46	1.03	35.44
80	18.63	19.89	6.88	1.62	.93	[.00	.20	.00	.00	T	.00	1.85]	50.00
81	[1.60	3.82	3.27	1.50	.41	.00	.05	-	.00	.70	3.70][1]		
AV	4.85	4.65	4.70	2.51	.40	.07	.36	.47	.38	.79	3.07	4.56	26.81

[1] Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 16 months with below-normal rainfall and a total deficit of 14.85 inches, or 54 percent of normal for that period.

PRECIPITATION AT HENSHAW DAM 2700 Ft. (Palomar R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	1.34	1.03	8.65	1.30	.00	.00	.03	.53	.00	.00	3.74	6.78	23.40
71	1.95	1.24	.95	1.93	1.83	.00	.00	.85	.17	2.02	.31	9.49	20.74
72	.00	.54	.00	.88	.86	.81	.00	.29	.22	1.65	4.49	4.38	14.12
73	2.84	5.05	10.23	.40	.38	.05	.00	.05	.00	.00	3.35	.35	22.70
74	9.01	.23	2.75	1.02	.13	.00	1.03	.01	.06	3.09	.25	3.40	20.98
75	.41	2.55	7.25	4.77	.39	.06	.00	.00	1.76	.46	4.55	.90	23.10
76	T	8.49	3.23	3.05	.42	.07	2.44	.00	4.58	.48	.73	1.54	25.03
77	4.56	.72	3.68	.40	3.33	.03	.00	4.30	.00	.26	.00	5.11	22.39
78	12.46	10.39	14.71	2.65	.36	.00	.00	.05	1.11	.00	5.64	6.37	53.74
79	8.08	7.18	9.11	.04	.40	.00	1.42	T	T	2.32	.28	.73	29.56
80	18.77	19.79	7.93	1.80	1.28	[.00	.00	T	.00	.00	.00	1.27]	50.84
81	[2.45	4.26	7.95	1.52	.55	0	T	.85	.00	.80	1.86][1]		
AV	4.23	3.73	3.89	2.33	.53	.07	.17	.48	.26	.70	2.57	3.69	22.65

[1] Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 13 months with below-normal rainfall and a total deficit of 5.39 inches, or 80 percent of normal for that period.

PRECIPITATION AT CORONA 610 Ft. (Trabuco R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	1.47	2.28	2.99	.17	.00	.00	.00	.00	.00	T	2.44	3.29	12.64
71	.55	.83	.13	.47	.31	.00	.00	.00	.00	.46	.07	5.73	8.55
72	.00	.15	.00	.78	.03	.47	.00	.36	.03	.39	2.21	2.02	6.44
73	2.53	4.81	3.62	.00	.00	.00	.00	.04	.00	.05	1.30	.15	12.50
74	4.70	.31	2.43	.26	.71	T	T	.00	.00	.33	.00	3.45	12.19
75	.26	1.24	2.87	1.47	.00	.00	T	.00	T	.03	.40	.33	6.60
76	.00	3.51	1.07	.60	.25	.12	.03	.00	2.07	.19	.80	.30	8.94
77	2.87	.92	.95	.01	1.24	.00	.00	1.84	.00	.01	.04	3.35	11.23
78	6.99	7.57	5.23	1.51	T	.00	.00	T	1.46	.04	1.87	1.76	26.43
79	4.85	2.77	3.83	.00	.01	T	T	T	.00	.50	.15	.73	12.84
80	6.25	9.98	4.06	.37	.12	[T	.00	.00	.00	.00	.00	.46]	21.24
81	[1.87	1.13	1.85	.51	.18	.00	.00	.00	T	.58	1.43][1]		
AV	2.37	2.17	1.71	1.06	.19	.02	.04	.06	.19	.71	1.48	1.83	11.41

[1] Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 17 months with below-normal rainfall and a total deficit of 6.32 inches, or 56 percent of normal for that period.

PRECIPITATION AT YORBA LINDA 350 Ft. (Trabuco R.D.)

	J	F	M	A	M	J	J	A	S	O	N	D	TOT
70	2.21	1.51	2.80	.08	.00	.01	.00	.00	.00	.00	3.72	3.19	13.52
71	.60	.58	.40	.40	.31	.03	T	.00	.00	.06	.27	6.58	9.23
72	T	.14	.00	.42	.09	.18	.00	.40	.07	.28	3.96	1.86	7.40
73	2.89	5.33	3.05	T	.06	.00	.00	.00	.01	.10	1.79	.55	13.78
74	6.37	.19	3.53	.42	.14	.00	.00	.00	.00	.65	.02	4.44	15.76
75	.23	2.61	3.95	1.80	.05	.00	.00	.00	.00	.36	.41	.30	9.71
76	.00	3.55	1.85	1.08	.08	.51	.01	.00	2.37	.00	.62	.79	10.86
77	3.20	.60	1.40	.00	2.42	.00	.00	2.61	.05	.00	.03	5.62	15.93
78	8.69	9.63	6.98	1.80	.02	.00	.00	.00	1.20	.20	1.98	2.84	33.34
79	7.85	2.75	6.68	.00	.16	.02	.00	.03	.00	.97	.30	.44	19.20
80	8.87	11.69	4.70	.41	.25	[.00	.00	.00	.00	.00	.00	.72]	26.64
81	[-	1.73	2.93	.27	.07	.00	.00	.00	.00	.63	2.14][1]		
AV	2.89	2.62	2.24	1.35	.21	.03	.02	.08	.20	.29	1.80	2.31	14.04

[1] Precipitation during the 18-month (June 1980 through November 1981) period bracketed shows 15 months with below-normal rainfall and a total deficit of 7.97 inches, or 52 percent of normal for that period.